HYBRID PROPULSION SYSTEMS DEVELOPMENT

Robert A. Kost
Vehicle Systems Team Leader

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ABSTRACT

Hybrid Propulsion Systems Development is an element of an overall DOE Advanced Vehicle System Program. The goal and objectives of the Advanced Vehicle System Program are:

Goal: Develop and validate vehicle system technologies which will facilitate production of competitive, consumer acceptable, automobiles having revolutionary improvements in fuel economy while meeting projected statutory emission and safety standards and having capability to use domestically produced alternative fuels.

Objectives:

1. Develop and validate by 1998 production feasible hybrid propulsion subsystem technologies for mid-size automotive applications that can achieve 50 mpg, meet EPA Tier II emissions requirements, and retain all the attributes and features of comparable competitive vehicles.

2. Develop and validate by 2004, production feasible vehicle system technologies for mid-size automotive applications that can achieve 80 mpg, meet EPA Tier II emissions requirements, and retain all the attributes and features of comparable competitive vehicles.

The ongoing hybrid propulsion development effort is focussed on the first objective.

Description: The main thrust of the hybrid propulsion development effort is to support, multiple competitive, domestic industry "teams" in developing and demonstrating hybrid propulsion systems that could be commercialized in the 2000 to 2003 time frame. Hybrid propulsion research and development projects with General Motors Corporation, Ford Motor Company, and Chrysler Corporation form the key part of DOE's hybrid propulsion systems development effort. These projects, supported by the Office of Advanced Automotive Technologies, are conducted under 50/50 cost-shared subcontracts between each of the three auto firms and their suppliers, and the DOE through the Midwest Research Institute (MRI). The MRI manages and operates DOE's National Renewable Energy Laboratory in Golden, Colorado. More than 30 subcontractors compose the three development teams that are headed by General Motors,

Ford Motor Company and Chrysler Corporation.

The hybrid propulsion concept combines two or more energy conversion technologies (e.g., heat engines, generators, and motors) with energy storage technologies (e.g., batteries, ultracapacitors, and flywheels) to provide vehicle propulsion. The hybrid propulsion system is designed to take advantage of the strengths of each constituent technology, resulting in vehicle systems with competitive performance, range, environmental, and economic characteristics; and superior efficiency over todays' automobiles.

Status: The hybrid propulsion systems development effort is entering its fourth full year of operation. Progress has been made in every technical area as well as in the partnership among the organizations which have undertaken this challenge. This year the Chrysler Corporation was awarded a subcontract for hybrid propulsion system development. The goals and terms of the Chrysler subcontract are very similar to the existing subcontracts with Ford and General Motors, although the time frame is compressed. The letter subcontract with Chrysler was signed on March 1996 and the contract is scheduled to run through December 1999.

Also notable during the past year was a technology sharing agreement and a series of information exchange meetings that were held between the systems developers. There are many areas where pre-competitive technology can be shared to conserve on resources and for the mutual benefit of all, and that sharing of knowledge is now taking place among system development teams.

The focus this year continues to be on developing production feasible hybrid propulsion systems capable of achieving 50 mpg in a vehicle, while maintaining all the safety, driveability, cost and other customer desired attributes. The 50 mpg target is an intermediate milestone in the longer term goal of demonstrating 80 mpg. Major propulsion subsystem technologies are being developed under the DOE cost-shared contracts. Complete hybrid propulsion subsystems have been integrated into test mules, which are modified conventional vehicles, and are currently undergoing evaluation. These test mules are scheduled to be delivered in FY 1998 and 1999. The purpose of these contracts is to validate technologies that yield up to 100% (50 mpg) improvement in fuel economy over today's conventional vehicles. The major technologies under development are in heat engines (gas turbines, Stirling, and diesels), energy storage (high power batteries, and ultra-capacitors), and power electronics. Major down selection decisions have been made in every component area. Internal combustion spark ignition engines, wheel motors, fuel cells, flywheels, and all battery chemistries other than lead acid have been eliminated from consideration for the 50 mpg vehicle system. Factors supporting these decisions have included both technical and business considerations including the maturity of the technology.

The General Motors, Ford and Chrysler presentations in this session will give more details on the status to date.

Enabling Technologies: The three new supporting component technology programs were initiated last year in the areas of power electronics, high power batteries, and flywheels.

The Department of Energy (OAAT) and the Office of Naval Research have teamed to improve

the U.S. power electronics industry. Cooperating with other agencies and DOD programs through the PEBB program, the program is currently identifying a high degree of requirements similarity between power systems for transportation, the DOD "More Electric initiative" and other industrial power needs. Systems level development and demonstration of this technology is done at the Oak Ridge Power electronics center and the Naval Surface Warfare Center in Annapolis, Md. The OAAT is currently defining a baseline automotive controller with representatives from the Ford SRL, Chrysler Liberty, and GMR. The results of this exercise will be combined with similar specifications currently underway at Army, Navy, Air Force, and NASA and with the involvement of the Virginia Power Electronics Consortium to define the most common denominator.

See the session write-up in this book for a more detailed discussion of the Power Electronics Program.

The USABC expanded their efforts this year and through a Cooperative Agreement between the United States Advanced Battery Consortium (USABC) and the Department of Energy (DOE), the USABC is focusing on the development of high-power batteries and ultracapacitors for the Partnership of New Generation of Vehicles (PNGV). Technologies being developed are nickel-metal hydride and lithium based battery systems and carbon based ultracapacitors. Full-capacity 400V energy storage systems will be engineered for delivery and integration into test-bed vehicles for technology validation. Four six-month Phase 1 contracts have been awarded to SAFT America, Inc, SRI International, Yardney Technical Products, Inc., and VARTA to establish the baseline high-power performance characteristics for nickel-metal hydride and the lithium-based technologies.

The DOE Flywheel Program supports a combined effort of the DOE, DARPA, and industry working cooperatively to overcome challenges associated with flywheel systems. DARPA is focusing on the development and procurement of flywheel hardware while the Department of Energy is providing the modeling and analytical capabilities for safety and containment. As of April 1996, LLNL and ORNL began R&D efforts in the area of safety and containment. In addition, cost reduction is being addressed for several of the key component technologies (composite materials, power electronics, and magnets).

See the session write-up for a more detailed discussion of the High Power Energy Storage Program.

Visual Management System: Communication is imperative in the course of developing a new system such as the hybrid. Today's electronic media provides a tremendous potential for improved communication both within programs such as the hybrid and to the public. This year the "Visual Management System" was improved and expanded to include new sections on safety and emissions issues and an interactive simulation model, the hybrid simulator (HEV ADVISOR). The Web site address is: *http://www.hev.doe.gov.* NREL's Center for Transportation Technologies Studies (CTTS) has also developed a Web site that ties together all the previously developed Web Sites and links together the HEV, Alternative Fuels Data Center, Clean Cities, and the new Transit-on-Demand Web sites. The address is: *http://afdc3.nrel.gov/CTT/ctt.html.*

More information about the DOE hybrid propulsion development effort can be found on the OAAT hybrid Web page: *http://www.ott.doe.gov/program/oaat/hev.html.*

Advanced Vehicle System Program Future: The program activity is being expanded in scope and transitioning from propulsion subsystem technology development (Phase I) to vehicle system technology development targeted at the 80 mpg objective (Phase II). This will require a total vehicle systems level approach.

This impacts the program in that the current effort will transition from the 50 mpg target to the 80 mpg target (often referred to as 2x and 3x respectively). This transition is planned to be completed during 1998. The transition will be seamless so that the propulsion system work accomplished in the Phase I, 50 mpg effort, is captured and built upon for the Phase II, 80 mpg effort. The Phase II effort will be aimed at further advances in the hybrid propulsion system combined with other automotive technology advances to achieve the 80 mpg objective by 2004. Though details are currently being worked out, the current plan calls for the efforts with General Motors, Ford, and Chrysler to be extended to develop and validate the technology necessary to achieve the 2004 objective. These program efforts will be supported by parallel development of some of the priority advanced enabling technologies.